On the Function of the Digestive Gland in *Nassarius*

(Gastropoda: Prosobranchia)

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(1 Plate)

THE DIGESTIVE GLAND of mollusks is generally considered to be an organ in which absorption of ingested food occurs. Recently MARTOJA (1961a and b, 1964) has reported that in the carnivorous European neogastropod *Nassarius reticulatus* (LINNAEUS, 1758), the digestive gland is not an organ of absorption. Neither food, nor reagents ingested with food, appear in the lumina of the glandular tubules, and there is no sign of apical absorption by the cells of the tubules. Food is absorbed through the epithelia of the stomach and intestine, and only then is delivered to the cells of the gland for further processing. The observations reported here indicate that in three American species of *Nassarius,* ingested reagents, and probably food, enter the ducts of the digestive gland from the stomach and then proceed into the lumina of the tubules of the gland where absorption occurs.

METHODS

Nassarius fossatus (GOULD, 1850) and *N. tegula* (REEVE, 1853) were collected from bays in San Diego, California. *Nassarius obsoletus* (SAY, 1822) was obtained by air express from the Marine Biological Laboratory, Woods Hole, Massachusetts. Animals were starved for from 1 to 14 days, and then were fed on flesh of the mussel, *Mytilus edulis* LINNAEUS, 1758, thoroughly mixed with reagents (colloidal graphite, carmine powder, rice starch grains, titanium dioxide powder) identifiable in the light microscope. After definite periods of digestion, specimens either were shelled and fixed without dissection, or were shelled and dissected before fixation, or were immersed in liquid nitrogen before shelling and fixation. Fixatives employed were 10% formalin in sea water, Bouin's fluid, formalin-ethanol-acetic, and SUSA. Paraffin sections were taken at 4 to 10μ, and stained in Lugol's iodine or in Mayer's hemalum.

RESULTS

The digestive gland in *Nassarius* is a large acinous structure, the tubules of which are furnished with lumina that communicate through ducts with the stomach. The glandular cells separate the lumina from the blood (Figure *1*). Material may enter the glandular cells apically from the lumina, or basally from the blood. In 104 of the 153 animals examined, the reagents utilized were found in the tubule lumina (Figure *1*). In considerable numbers of animals, the reagents were present in the lumina in quantity 30 min. or less after ingestion. Colloidal graphite, the reagent usually employed, was found within the cells of the digestive gland tubules in 43 specimens of the 3 species. The reagent ordinarily was concentrated apically (Figure 2), although cells which contained graphite distributed throughout their length were often seen. Generally the graphite appeared in the cells from 30 to 45 min. after it was found in the tubule lumina. Carmine was observed within the cells of a few specimens. Titanium dioxide powder and rice starch grains were fed to a few animals, and while not seen within the tubule cells, were in each case to be found within the lumina of the tubules. At times the reagents were seen in small quantities in the blood spaces within the digestive gland; but since there was never an indication of a basal absorption by the glandular cells (i. e., a basal intracellular concentration of the reagent), I regarded the occasional occurrence of the reagents in the blood spaces as an artifact induced during dissection or other tissue processing.

In 49 animals, the reagents ingested were not found within the tubule lumina. Some of these specimens were fixed after very short periods of digestion, and it is assumed that sufficient time for the materials to reach the lumina had not elapsed. In other cases it was evident from inspection of sections of the stomach contents that the amount of reagent ingested was small when compared with the quantity of food taken in, and it is reasonable to suggest that the sections taken showed regions of the digestive gland to which only food had been delivered.

DISCUSSION

It is possible that on occasion the stomach contents may be forced into the entrances of the main ducts of the digestive gland by spasmodic muscular contractions during fixation (Owen, 1956); however, I do not consider the occurrence of ingested materials in the lumina of the many tubules in such a large number of animals to be an artifact. In a number of cases liquid nitrogen was employed as an immobilizing agent prior to fixation, and I do not consider it likely that during or after such treatment, spasmodic muscular contractions could occur to such an extent that they would produce the observed phenomena.

It is reasonable to assume that when ingested reagents are found in the lumina of the tubules, they have been accompanied there by food, and that a subsequent apical concentration of the reagents indicates that food has been absorbed from the lumina. Absorption of material from the lumina by the tubule cells, with subsequent apical concentration, is a common occurrence in mollusks (Fretter, 1937, 1939; Graham, 1932, 1938; McLean, 1970; Morton, 1955a, 1955b; Oldfield, 1955; Owen, 1955; Vonk, 1924); and it is generally accepted that absorption of ingested reagents shows a pathway for the uptake of food. It is conceivable that the absorption of extraneous material such as graphite is an excretory device; but the common occurrence of extracellular digestion in carnivorous gastropods (Owen, 1966) suggests that soluble materials derived from the food are to be found in the glandular lumina along with the ingested reagents. It is likely, therefore, that in such a region of active absorption some uptake of food does occur.

Martoja (1961a, 1961b, 1964) has shown that in *Nassarius reticulatus* materials are absorbed at the level of the stomach and intestinal epithelia. It appears that in the 3 species investigated here, uptake of food also occurs in the tubule cells of the digestive gland.

ACKNOWLEDGMENTS

I thank Dr. Mary E. Clark for a critical reading of the manuscript, Dr. Daniel L. Lindsley for the use of photographic equipment, and Dr. George E. Radwin for helpful comments. This work was supported in part by a grant from the San Diego State College Foundation.

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Plate Explanation

Nassarius fossatus (Gould, 1850)

Figure 1: Tubule of the digestive gland. Mayer's haemalum. B, blood space; L, lumen of the tubule; arrow, ingested carmine in the lumen, 18 minutes after feeding (× *ca.* 400)

Figure 2: Cells of a tubule. Mayer's haemalum. L, lumen of the tubule; arrows, ingested colloidal graphite concentrated in apical regions of cells, 75 minutes after feeding (× *ca.* 1 200)